

by 10dB to maintain the same co-channel interference ratio as in the narrower band services.

3. The level defined in item 1 can be exceeded provided that the protections of item 2 are satisfied.
4. For non-co-channel interference scenarios, increase the allowable field strength of item 2. by an amount equal to the coupled power for the particular configuration of concern.

The guidelines above are modeled after the approach taken at 821-824 MHz. Some minor differences do exist, however. The planning methodology has been updated to reflect the latest standard (TIA TR8 WG8.8). Item 3 is a slight modification of the 821-824 MHz methodology allowing more signal level at the service area edge as long as there is no significant co-channel interference.

3.9 Channel Loading Requirements

Channel loading requirements should not be defined in the FCC rules. However, public safety regional planning groups will need guidelines to ensure efficient use of the available spectrum.

4. Interference Between Systems

All coupled power measurements defined in this section are to be measured at the input to the transmitter's antenna and at maximum transmitter power except as specifically noted. For TDMA systems, the measurements are to be made under TDMA operation only during time slots when the transmitter is on.

4.1 Interference into Other Systems

Interference into other systems from the public systems is defined by the proposed integrated voice and data specifications in sections 2.4.1 and 2.4.2. These specifications are believed to place relatively tight limits on out of band emissions and should not cause problems for adjacent systems.

4.2 Intrasytem Interference

Spectrum for wideband mobile stations can only be allocated between 798.5 MHz and 801.5 MHz unless there is no other wideband spectrum available and the following can be shown:

Mobile Station Transmitter

The wideband mobile station's transmitter coupled power measured in a 6.25 kHz bandwidth at 796.49375 MHz or 803.50625 MHz is less than -80dBc at maximum transmitter power and the maximum absolute power is less than -60dBm at maximum power reduction when the wideband mobile station is transmitting on it's closest assigned frequency to 796.5 MHz and 803.5 MHz respectively.

Spectrum for wideband fixed stations can only be allocated between 768.5MHz and 771.5 MHz unless there is no other wideband spectrum available and the following can be shown:

Fixed Station Transmitter

The wideband fixed station transmitter coupled power measured in a 6.25 kHz bandwidth at 766.49375 MHz or 773.50625 MHz is less than -85dBc when the wideband fixed station is transmitting on it's closest allocated frequency to 766.5 MHz or 773.5 MHz respectively.

4.3 Intersystem Interference

Mobile and fixed stations transmit noise outside of their intended frequency of operation. This noise can extend over a very broad band and can limit the range of other communication services. Therefore, out of band noise must be restricted to minimize the impact on critical public safety communications.

The following analysis is based on the assumption that the commercial spectrum is laid out with the same mobile station and fixed station frequency constraints as public safety. Namely, that the commercial mobile transmit band is allocated 776-794 MHz and it is paired with the mobile station receive band at 746-764 MHz. We recommend that this be done. It should also be noted that the limitations on interference into public safety systems from other systems is consistent with the interference allowed between integrated voice and data systems as proposed in section 2.4.1 and 2.4.2.

There are several intersystem interference scenarios associated with the public safety allocation.

At 806 MHz, there is an interface between the public safety mobile station transmitter allocation and the land mobile station transmitter allocation. Since the allocations immediately above and below 806 MHz are both mobile station

transmit bands and they are both narrowband systems, the interference potential is minimized and no additional requirements are necessary

A second interface exists at 776 MHz between the public safety integrated voice and data mobile station receive allocation and the commercial mobile station transmitter allocation. The key issue for this interface is the interference caused by the commercial mobile station transmitter into the public safety mobile station receiver. When a commercial mobile station transmitter operates in close proximity to a public safety mobile receiver, it can increase the noise floor of the public safety receiver causing degraded or lost communication. This could occur at an emergency site where many types of communications devices might be used simultaneously

The level of interference that is acceptable in this situation is affected by a number of factors such as the minimum path loss between the mobiles, the probability that a commercial mobile transmitter is at a distance from the public safety receiver where it will cause interference and the probability that the public safety mobile is close to its limit of coverage. Some of these factors are difficult to estimate.

While the minimum path loss could be arbitrarily defined at some mobile to mobile spacing along with a maximum allowable receiver degradation, the resulting specification could be unnecessarily tight and could be unrealizable in practical equipment. The approach taken here is to determine the requirement based on the experience with public safety systems in other bands. Since public safety transmitters in other bands also transmit broad band noise that increases the noise floor of the public safety receivers in that band, the level of transmitter noise in the public safety mobile station should be acceptable for a commercial mobile transmitter in the new band.

A number of current public safety mobile transmitters (portables) have been measured and the transmitter noise in the receive band is -110dBc measured in a 6.25 kHz bandwidth. Typical portable radios have 3w transmitters. The resulting noise in the receive band is -75dBm in a 6.25 kHz bandwidth when measured at the input to the antenna. This level of noise has not caused any significant problems in existing systems.

Therefore, the commercial mobile station transmitter's absolute coupled power must be less than -75dBm at 775.99375 MHz or anywhere in the public safety mobile station receive band when measured in a 6.25 kHz bandwidth. This coupled power requirement must be met by the commercial mobile station without power control active and with the transmitter operating at its closest allocated frequency to 775.99375 MHz.

It should be noted that this specification also does not ask for lower interference from other systems than it requires between public safety systems. The proposed specification in section 2.4.1 of -70dBm in a 30 kHz bandwidth (-77dBm in a 6.25 kHz bandwidth) for transmit noise in the receive band is about the same as required of other systems(-75dBm). Since public safety system and commercial system base sites are not coordinated, the advantages associated with power control are not available and therefore the commercial system must meet this specification at maximum transmitter power.

A third interface exists at 794 MHz between the public safety integrated voice and data mobile station transmit allocation (fixed station receive allocation) and the commercial mobile station transmit allocation. The key issue for this interface is the interference caused by the commercial mobile station transmitter into the public safety fixed station receiver. When a commercial mobile station transmitter operates in close proximity to a public safety fixed station receiver, it can increase the noise floor of the public safety receiver. This is a particularly severe type of interference because the interferer reduces the sensitivity of the public safety fixed station causing a loss of range for the system. This can prevent communication to **any** mobiles at larger distances from the fixed site.

A reasonable worst case level of interference generated by the commercial mobile station transmitter causes a 3dB degradation of the public safety fixed station receiver's noise floor. A typical receiver will have a 6.25 kHz receiver bandwidth and a 10dB noise figure resulting in a noise floor of -126dBm. Worst case interference occurs when the path loss is minimum. A minimum mobile station antenna port to fixed station antenna port path loss (independent of the antenna gains) for moderate base heights of 100-200 feet is 75dB. This has been measured in field tests in the 800 MHz band. Therefore, the commercial mobile station transmitter's absolute coupled power must be less than -51dBm at 794.0625 MHz or any frequency within the public safety fixed station receive allocation when measured in a 6.25 kHz bandwidth. This coupled power requirement must be met by the commercial mobile station without power control active and with the transmitter operating at its closest allocated frequency to 794.0625 MHz.

It should be noted that this requirement is also consistent with the proposed specification in section 2.4.1 for interference between public safety systems of -50dBm absolute coupled power in a 25 kHz bandwidth (-56dBm in a 6.25 kHz bandwidth) at a frequency offset of 37.5 kHz. Again, since public safety system and commercial system base sites are not coordinated, the advantages associated with power control are not available and therefore the commercial system must meet this specification at maximum transmitter power.

A fourth interface exists at 764 MHz between the public safety mobile station receive allocation and the commercial fixed station transmitter allocation. The

key issue for this interface is the interference caused by the commercial fixed station transmitter into the public safety mobile station receiver. A 10dB degradation of the public safety mobile station receiver's noise floor caused by the commercial fixed station's transmitter under worst case conditions will be used in this case since this type of interference causes a small circle of interference around an interfering base station and not a more severe range loss of the entire system. A typical receiver would have a 6.25 kHz receiver bandwidth and a 10dB noise figure resulting in a noise floor of -126dBm. Worst case interference would occur when the path loss is minimum. A minimum path loss of 75dB is used again for the mobile station to a fixed station path. Therefore, the commercial fixed station transmitter's absolute value of coupled power must be less than -41dBm at 764.0625 MHz or at any frequency within the public safety mobile station's receive allocation when measured in a 6.25 kHz bandwidth. This coupled power requirement must be met by the commercial fixed station with the transmitter operating at it's closest allocated frequency to 764.0625 MHz.

Again, this specification is consistent with the public safety specification in section 2.4.2 of -80dBc in a 30 kHz bandwidth (-87dBc in 6.25 kHz bandwidth). A typical power into the fixed station antenna of 30w (+45dBm) with -87dBc coupled power results in -42dBm at frequency offsets greater than 400 kHz.

5.0 Spectrum Sharing Recommendations

During the transition of this band from TV to public safety, it is desirable to allow public safety to share spectrum with TV. The following section discusses the changes that can be made from the sharing approach used for UHF-TV and the recommendations for sharing in this band.

5.1 Path Loss

The frequencies in the 746 to 806 MHz band have greater propagation path losses than those in the 470 to 512 MHz band. Therefore, the required spacing between TV stations and land mobile stations in the new band should be reduced for the same land mobile ERP and/or the allowed ERP should be increased. These changes should cause no perceived impact on viewers of over-the-air television.

The R-6602 propagation curves determine the field strength, E in $\text{dB}\mu$, as a function of distance from a 1 kW ERP station at various station heights and a receiver height of 30 feet. Knowing E , by the subtraction of the term $75 + 20 \log(f)$, where f is the frequency in MHz, the power in dBm out of a matched half wave dipole is obtained. Finally, with the 1 kW transmitted ERP, the propagation path loss, PL in dB, between half wave dipoles is easily obtained:

$$PL = 75 + 20 \log (f) + 60 - E \text{ dB}$$

Using the computer algorithm in FCC/OCE RS76-01 for the R-6602 curves, the field strength was determined for various distances at the frequencies of 491 and 776 MHz, the mean frequencies of the two bands of interest. This was modified to obtain the path loss as shown above. The difference, independent of distance or base height is 5.3 dB.

The difference in propagation path loss was also determined at the two frequencies by using the curves of Okumura over the same parameters, and the difference was 5.3 +.8/- .5 dB. We thus conclude that it is valid to use a factor of 5.3 dB attributable to propagation to shorten spacings between land mobile systems and TV and/or to increase the power allowed by land mobile systems in the new 746 - 806 MHz band.

5.2 Front to Back Ratio

An additional factor that reduces the interfering signal from land mobile transmitters into TV receivers is the front to back ratio of the TV receiving antenna. This too should be included in the determination of ERP and spacing between the TV station and land mobile transmitters.

In the First Report and Order of Docket 18261 (adopted May 20, 1970), in paragraph 61, the Commission referenced a front to back ratio of 10 to 15 dB for the TV receiving antenna. In that proceeding this factor was taken as a conservative measure of margin to assure the success of the new sharing. That success is now history, and as we go forward, it is appropriate to determine whether that interference margin could be reduced.

Measurements have been made in a cluttered environment of the antenna pattern of a typical TV receiving antenna. When the front to back ratio and cross polarization are taken into account, the average protection toward the rearward direction was well in excess of 20 dB. Thus, 15 dB is still a conservative factor to use in protection computations, and it will be used here.

5.3 Other Factors

There are additional margin factors that were implemented in the Docket 18261 sharing that are retained here, continuing to provide a conservative sharing environment. These include:

- 1) Assuming that all mobile and control stations operate at a height of 100 feet AAT.
- 2) Ignoring the effects of cross polarization discrimination between the signals of the two services (which can be 10 to 20 dB).
- 3) Using the R-6602 curves which are known to predict coverage where the actual signal is less (the predicted contour that is being protected is often beyond where TV viewers may find the TV signal acceptable.)
- 4) Ignoring the improved performance of TV receivers.

Thus, we conclude that the use of the 40 dB protection curves from the existing FCC rules with a reduction in the margin of $5.3 + 15 = 20.3$ dB will allow sharing while still maintaining a level of margin that will assure successful performance.

5.4 Proposed Implementation

5.4.1 Proposed Co-Channel Allowed Power

The following table was produced by increasing the allowed power in Table B of paragraph 90.309 of the FCC rules by $5.3 + 15 = 20.3$ dB up to a maximum of 1000 Watts ERP. It was extended to shorter distances using the R-6602 algorithm described above and the planning factors contained from FCC docket 18261 First Report and Order adopted May 20, 1970.

It is proposed that the basic procedure for the use of Table B in paragraph 90.309 also be followed for the use of this table for co-channel spacing, where the indicated spacing is in the direction of the Grade B contour of the protected TV station.

**TABLE 1 BASE STATION MAXIMUM ERP (40 dB PROTECTION)
FOR CO-CHANNEL SEPARATION INDICATED**

DISTANCE*	(40 dB PROTECTION) Maximum Effective Radiated Power (ERP)									
	Antenna height (AAT)									
	50 ft. (15 m)	100 ft. (30 m)	150 ft. (45 m)	200 ft. (61 m)	250 ft. (76 m)	300 ft. (91 m)	350 ft. (106 m)	400 ft. (122 m)	450 ft. (137 m)	500 ft. (152 m)
90 mi. (145 km)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
85 mi. (137 km)	1000	1000	1000	1000	1000	1000	1000	1000	975	804
80 mi. (129 km)	1000	1000	1000	1000	1000	771	568	439	343	279
75 mi. (121 km)	1000	1000	870	516	348	246	179	138	110	89
70 mi. (112 km)	1000	561	261	146	94	64	47	36	29	24
65 mi. (105 km)	370	148	66	36	24	16	12	9	7	6

* Distance from the transmitter site of the protected NTSC UHF television station.

It is also necessary to determine the allowed power for the 746 to 806 MHz band when tower heights are above 500 feet AAT. This is presently done in the 470 to 512 MHz sharing band by using Figure B in paragraph 90.309. On the basis of the previous analysis, it should be possible to increase the power allowed there by 20.3 dB. This can be accomplished by moving the scale on the graph in Figure B up by 20.3 dB and decreasing the separation required in a consistent way. This has been done in the graph below which is followed by the data in tabular form.

It is recognized that useful, non-interfering service can occur at spacings less than the mileage presented in the graph and table following, namely below 90 miles and that these spacings can be determined on the basis of power reduction following the procedures that produced this graph and table.

In paragraph 90.307(b) of the existing sharing rules, an additional requirement is added when the height of the land mobile station is greater than 500 feet and when the distance to the Grade B contour of the protected co-channel TV station is less than the distance to the radio path horizon in that direction. It then must be shown that the terrain is such that the protection is provided by that means or that otherwise the required protection will be provided assuming free space path loss and further reducing the land mobile transmitted ERP in that direction. In consideration of the conservatism that was used and that no interference of substance has occurred in more than 25 years, it is recommended that this requirement be significantly relaxed for application to the 746-806 MHz band.

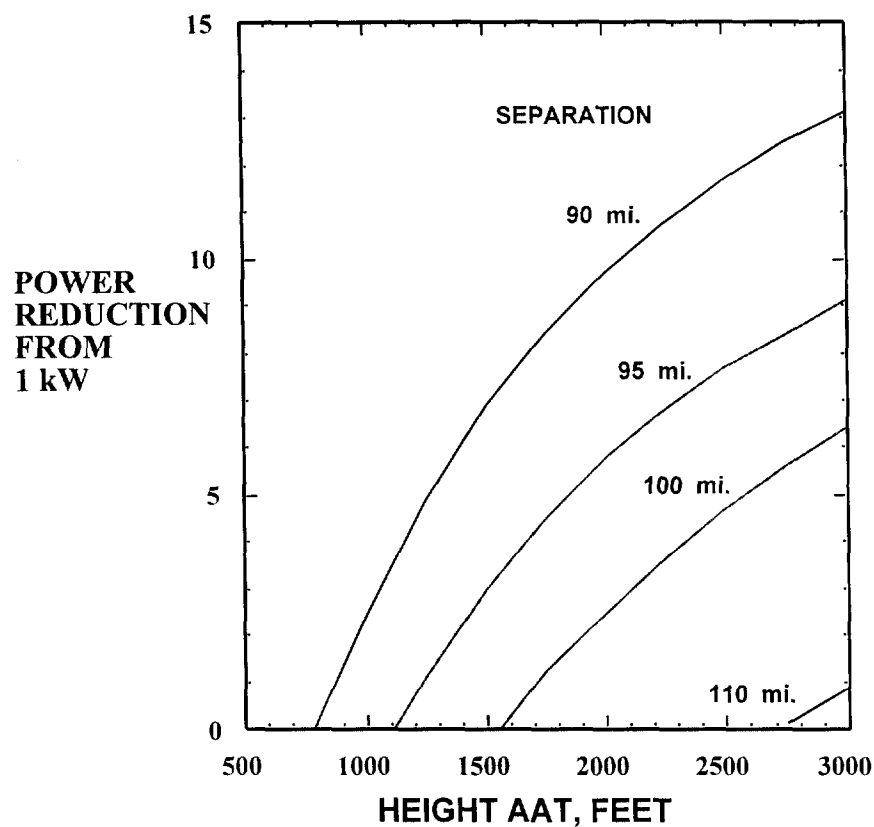


Table 2 Co-Channel Base Station ERP Reduction In dB

BASE STATION	(40 dB PROTECTION) POWER REDUCTION IN dB					
	DISTANCE IN MILES					
HEIGHT AAT	90	95	100	110	120	130
780	0	0	0	0	0	0
1000	2.5	0	0	0	0	0
1250	4.9	1.1	0	0	0	0
1500	6.9	3	0	0	0	0
1750	8.4	4.6	1.2	0	0	0
2000	9.7	5.8	2.5	0	0	0
2250	10.8	6.8	3.7	0	0	0
2500	11.7	7.7	4.7	0	0	0
2750	12.5	8.4	5.6	0.1	0	0
3000	13.1	9.1	6.4	0.9	0	0

* Power reduction in the direction of the protected TV station.

5.4.2 Proposed Co-Channel Allowed Mobile/Control Station Power

In like manner, the co-channel power as a function of distance can be determined for the mobile and control station by using the 20.3 dB factor. This is done in the following table based on Table D in paragraph 90.309 for 40 dB protection. At a distance of 100 miles or greater from the associated base station, the power of a mobile or control station can be at the maximum of 200 Watts ERP and meet the requirement of this section. At a spacing of 95 miles that power must be reduced to 100 Watts, and at 90 miles it must be reduced to 8 watts

Table 3 Mobile/Control Station
ERP Reduction in Power

DISTANCE FROM GRADE B		ERP OF MOBILE OR CONTROL STATION
MILES	km	
15	24	200
10	16	148
8	13	75
6	10	23
5	8	8
4	6	4
3	5	1

* Distance to mobile or control station.

5.4.3 Proposed Adjacent Channel Allowed Base Power

When the adjacent channel power allowed for base transmitters under Docket 18261, as set fourth in Table E of paragraph 90.309 of the rules, is adjusted by the 20.3 dB used above, the full ERP of 1000 Watts is allowed down to a spacing of 59 miles from the TV transmitter. Thus, no table is required for this parameter.

5.4.4 Considerations of Land Mobile Interference into NTSC vs DTV

Different planning factors are used for DTV as compared to NTSC. Of greatest impact is the reduced carrier to interference ratio (C/I) required for DTV. While NTSC signals require a C/I somewhere in the range of 40 dB for acceptable performance, DTV has been measured as requiring only a nominal 10 to 13 dB (see *digital* HDTV Grand Alliance System, Record of Test Results page I-3-27 and 28). The carrier to (thermal) noise ratio, C/N is also much better for DTV. Though the maximum allotted DTV transmitted power is 7 dB lower than NTSC, the net effect is a vast improvement in interference susceptibility.

But, considering that the actual implementation of the new service has not yet taken place, it is considered prudent at this time to use the same protection factors for DTV as recommended here for NTSC.

However, considering the eventual frequency relocation of DTV stations initiating operations in channels 60-69, station licensees will in many cases choose to never implement full service (allotted ERP) on these frequencies. It is therefore recommended that the FCC require, as soon as possible but no later than the first two-year progress review, that DTV licensees indicate what service/power level they will implement and that protection requirements be adjusted to those planned levels from the current allotment levels.

5.5 Proposal Impact

5.5.1 Resulting Interference of Land Mobile into TV

We now investigate the net effect of the proposed changes. First, we will compute the interference signal from the land mobile transmitter into a TV receiver. The receiver will be located in the channel 60-69 band where it receives the UHF Grade B signal strength of 64 dBμ. We assume a 9 dBd antenna with a combined front to back ratio and polarization discrimination on the rear 180 degrees of the pattern of 15 dB. There is also 2 dB of transmission line loss assumed. The resulting TV signal is:

64 dBμ	-68.8 dBm
Rx Antenna	9.0 dBd
Line Loss	-2.0 dB
Received Power from TV	-61.8 dBm

The power received from the land mobile transmitter is now determined:

"-40" dB FROM TV	-101.8 dBm
F(50,10) to F(50,50)	-13.9 dB
Power Increase Proposed	20.3 dB
Rx Antenna F/B & X Pol.	-15.0 dB
650/776 Frequency Shift	-1.5 dB
Received Power from LM	-111.9 dBm

The difference in the two signals is $111.9 - 61.8 = 50.1$ dB which is the ratio of the median desired TV signal to the median undesired LM signal. The calculation includes the recommendation of raising the interference level by 20.3 dB from the level produced by the existing "40 dB" sharing criteria. Historically, the median desired TV signal to the median undesired LM signal in the New York area (where 40 dB was used) would be an additional (20.3-5.3) dB or a total of $50.1 + 15 = 65.1$ dB, with never a problem.

This has been computed on the basis of a single LM transmitter and, under the real world sharing conditions, there will be many transmitters. However, many modulated transmitters cause less interference than a single CW source and that many modulated transmitters distributed across the band cause even less interference. Thus, this represents a valid comparison for that condition as well.

5.5.2 Interference of TV into Land Mobile

The interference of the TV station into a land mobile base receiver is assumed to now be computed as a function of distance using the R-6602 curves. The TV station will have an ERP of 1 MW at a height of 1000 feet, and the land mobile receiver with sensitivity of -118 dBm will have a 9 dBd receiving antenna with 15 dB of cross polarization protection. (More is possible, but it is assumed this will be in an antenna farm with many scatterers which produce cross polarized scattering to degrade the polarization protection.)

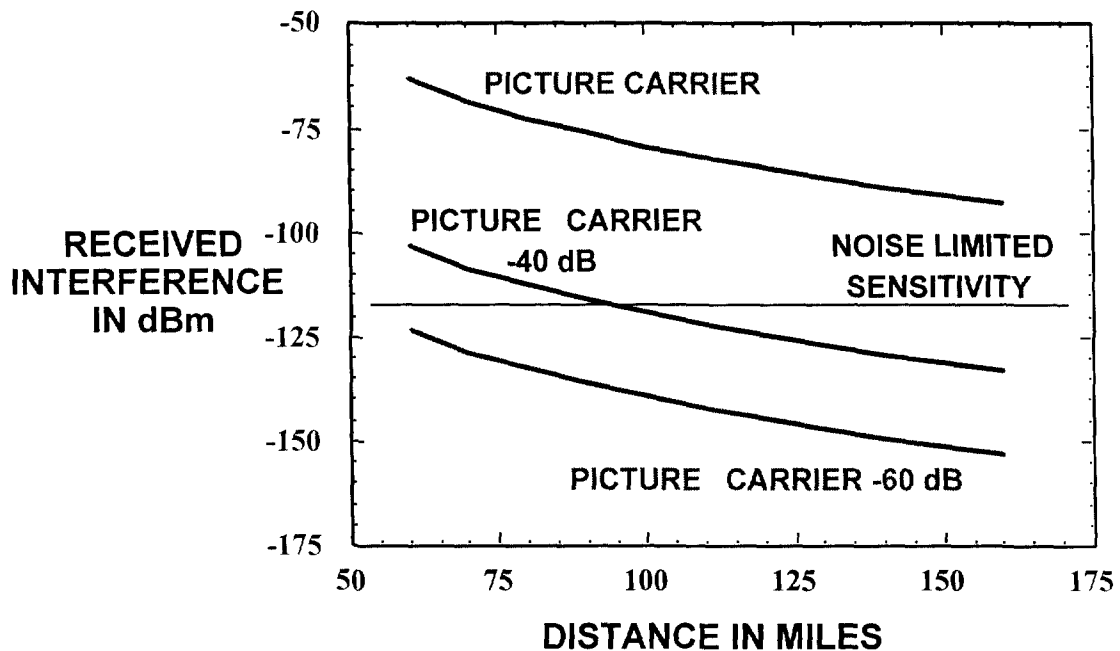
It is assumed in the R-6602 curves that the height of the receiver is 30 feet above ground. The correction for that factor which will be used is 6 dB per doubling of height. The factors that apply to this situation and their summation follow:

TV FIELD STRENGTH	FS dBμ
- 75 - 20 log (776 MHz)	-132.3 dB
LM ANTENNA HT 500' vs. 30'	+24.4 dB
LM ANTENNA GAIN	9.0 dBd
CROSS POLARIZATION	-15.0 dB
RCVD TV POWER	<hr/> FS - 114.4 dBm

This can be used in conjunction with a spectral plot of the TV signal to determine how much of the spectrum can be shared as a function of the distance of separation. A spectral plot of an NTSC station is shown in Appendix A to this report as taken over the air with a spectrum analyzer with 30 kHz resolution

bandwidth. Virtually all of the transmitted power is in the picture carrier, so that is what is used as the field strength reference for the received signal at the land mobile receiver. It is noted that there is a substantial range of frequencies, 3 MHz or more between the picture and sound carriers where the TV signal is reduced 40 dB or more. Directional and adaptive land mobile antennas may be used to provide additional protection of 20 dB.

The result is plotted below, and it is seen that there can be no sharing of spectrum on the picture carrier unless the separation between the TV transmitter and the land mobile receiver is much greater than 175 miles. However, due to the 40dB lower energy level away from the TV carrier, it is possible to use a significant portion of the spectrum with minimal degradation at spacings somewhat greater than 100 miles and with some degradation (a range reduction) at 70-100 miles. With an additional protection of 20 dB (60dB total), the central portion of the spectrum can be used at closer spacings. Alternatively, all of the TV channel can be used at distances somewhat greater than 100 miles except within approximately ± 200 kHz of the picture and sound carriers.





Date 08.Oct.'95 Time 23:14:56

Ref.Lvl -10.00 dBm Marker

-93.16 dBm

514.00 MHz

Res.Bw 30.0 kHz [3dB]

Vid.Bw 100 kHz

CF.Stp

1.000 MHz

RF.Att

Unit

20 dB

[dBm]

5.6

Appendix A

